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Architecture

ARCHITECTURE OF CRAFT CENTERS AS A MEDIATOR BETWEEN ORDER AND CHAOS IN SOCIAL AND ECONOMIC SYSTEMS

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Abstract

In the context of growing instability in social and economic processes, traditional forms of cultural activity increasingly find themselves at the intersection of order and chaos. Folk crafts, based on stable cultural codes and informal mechanisms of knowledge transfer, are confronted with the fragmentation of educational, production and market ties, which limits their potential for sustainable development. The article considers the architecture of folk craft centres as a mediating spatial system that allows us to trace the mechanisms of order formation from chaotic social interactions. The methodological basis of the study includes a theoretical and analytical approach, architectural and spatial analysis, and interpretation of folk craft centres as hybrid socio-economic ecosystems. The study identified architectural principles based on the spatial integration of education, production, and business, the flexibility of the planning structure, and the adaptability of the architectural environment. It was shown that such centres do not eliminate the variability of traditional craft practices but rather structure it, creating conditions for the sustainable transfer of knowledge and economic viability. The article is based on an analysis of the Kazakhstani context, but the proposed architectural principles are universal in nature and can be applied in other regions.

Introduction

Contemporary socio-economic systems are characterised by instability and non-linearity, which is why the category of "order-chaos" is viewed not as a static opposition, but as a dynamic interaction. Complexity theory shows that stable forms of order can arise from chaotic processes through self-organisation, without strict external control (Prigogine & Stengers, 1986). This approach allows us to rethink architecture as an active element of socio-spatial systems.

In this context, architecture can be seen as a mediator that structures interactions between diverse social and economic processes without eliminating their variability. This approach is particularly relevant when analysing traditional craft practices that combine stable cultural codes with informal forms of training, individual production and unstable market conditions. According to international approaches, traditional crafts belong to the living intangible heritage, the sustainability of which is determined by the continuous transfer of knowledge and adaptation to modern social conditions (UNESCO, 2003).

In post-traditional societies, including Kazakhstan, folk crafts often remain fragmented and poorly integrated into formal educational and economic structures. This limits their potential as a resource for sustainable development and cultural identity and points to the need for spatial models capable of linking traditional forms of knowledge with modern production and business mechanisms.

In theoretical models, the integration of education, production and economic activity is seen as an important condition for sustainable development (Leydesdorff, 2000). However, the spatial dimension of this integration remains underdeveloped, especially as it applies to the field of folk crafts.

In this article, folk craft centres are viewed as assemblages of diverse actors, practices and spaces that mediate between chaotic socio-economic processes and the formation of an emergent spatial order (DeLanda, 2006). Figure 1 presents a conceptual diagram illustrating the role of the architecture of such centres as a mediator between informal craft practices, market uncertainty and structured socio-economic systems.

The aim of the study is to identify the architectural principles of the formation of folk craft centres that ensure the integration of education, production, and business in conditions of dynamic order and chaos.

Materials and Methods

This study is theoretical and analytical in nature and aims to identify the architectural principles underlying the formation of folk craft centres as mediating spatial systems between chaotic socio-economic processes and the formation of a stable order. The methodology is based on an interdisciplinary approach that combines architectural theory, complexity theory, and research in the field of cultural and socio-economic development.

The research materials include scientific publications on the issues of order and chaos in complex systems, works that consider architecture as a socio-spatial mediator, as well as studies devoted to traditional crafts, the integration of education, production and business, and the cultural policy of the Republic of Kazakhstan.

The methodological structure of the study includes three interrelated levels of analysis. The first level involves theoretical analysis aimed at interpreting the category of 'order-chaos' as a dynamic interaction in which architecture is viewed as an element of a complex adaptive system capable of participating in the processes of self-organisation and the formation of emergent order.

The second level is represented by architectural and spatial analysis, which examines the functional and spatial relationships between the educational, production and commercial components of folk craft centres. Particular attention is paid to mechanisms of spatial mediation, flexibility of planning solutions and the possibility of adapting the architectural structure to changing social and market conditions.

The third level includes a socio-economic analysis that considers folk craft centres as elements of local cultural and economic ecosystems. The analysis aims to assess the role of the architectural environment in supporting knowledge transfer, cooperation between craftsmen, and the integration of craft practices into modern economic models.

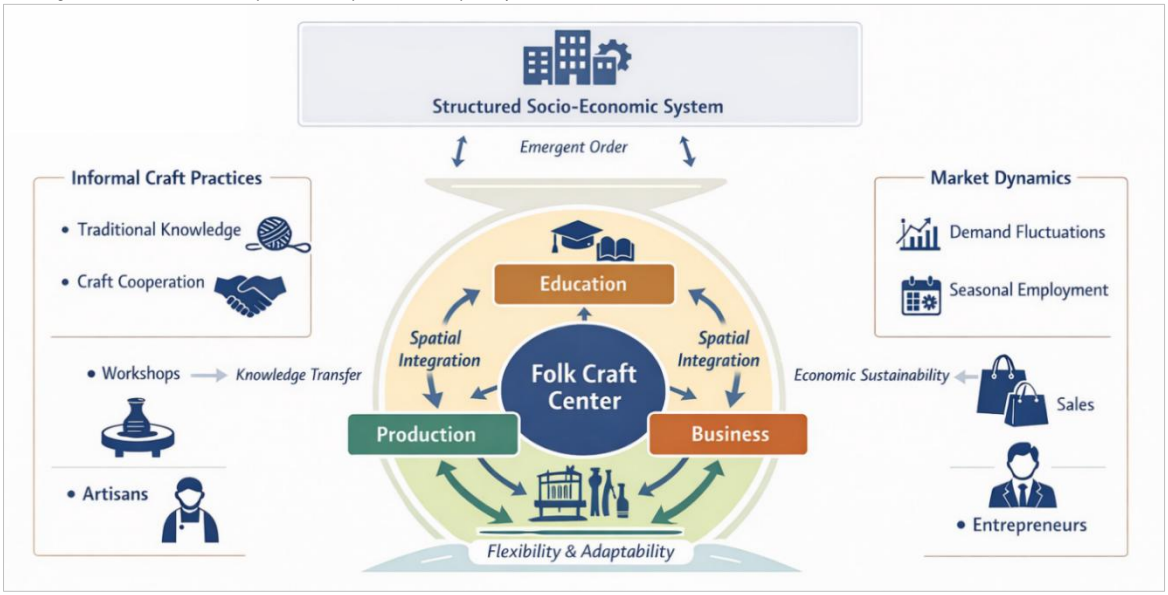
The results of the study are summarised in the form of conceptual diagrams and analytical tables reflecting key architectural strategies for mediating the dynamics of order and

chaos.

Results

The theoretical and analytical study revealed the architectural principles underlying the formation of folk craft centres, which mediate between chaotic socio-economic processes and the formation of a stable spatial order. The results are interpreted as generalised spatial models rather than solutions for individual design objects.

The key result is the identification of the need for spatial integration of educational, production, and commercial functions within a single architectural structure. Such integration makes it possible to overcome the fragmentation of craft practices and create conditions for their sustainable development. Figure 2 shows a spatial model of a folk crafts centre, in which the functional areas of training, production and sales are connected through common public spaces, ensuring constant interaction between the participants in the processes.



Pic 1. Spatial model of the center of folk crafts
Note: compiled by the authors using AI-based visualization tools

Spatial proximity and visual permeability between zones facilitate informal knowledge transfer and student involvement in production activities, which is consistent with the logic of recurring spatial patterns (Alexander et al., 1977).

The analysis showed that the architecture of folk craft centres should combine stability and flexibility. This balance is achieved by forming a stable spatial framework and transformable functional content. The architectural framework ensures the integrity and long-term sustainability of the centre, while flexible workshops, training and exhibition spaces allow it to adapt to changing social and market conditions. This approach is consistent with the concept of architecture as a system of 'supports' that allows for multiple scenarios of use (Habraken, 1999).

The results of the study also demonstrate the importance of the temporary adaptability of the architectural environment. Craft practices are subject to seasonal fluctuations and changes in the organisation of labour, which requires the possibility of gradual transformation of spaces. The use of modular and multifunctional solutions allows architecture to respond to these changes without losing structural integrity, ensuring the ability of buildings to 'learn' over time (Brand, 1995; Schneider & Till, 2007).

A separate set of results relates to the spatial organisation of knowledge transfer. Architectural solutions that combine formalised educational spaces with open workshops and demonstration areas are effective. This structure supports the transition from implicit craft skills to their understanding and formalisation, which corresponds to the dynamic model of knowledge creation (Nonaka, 1994).

From a socio-economic point of view, it has been established that folk craft centres can function as local production and economic clusters. The spatial concentration of craftsmen, educational functions and sales channels promotes cooperation, reduces transaction costs and increases the sustainability of craft practices in an unstable market (Porter, 1998).

A summary of the identified architectural strategies and their correspondence to various types of chaotic processes is presented in Table 1, which systematises the mechanisms of spatial mediation between informal practices and the formation of a sustainable socio-economic order.

Table 1. Architectural principles of mediating the dynamics of order and chaos in folk craft centres

Chaotic socio-economic processes	*Architectural strategies for mediation*	*The emerging spatial and socio-economic order*
Informal transfer of craft knowledge	*Open workshops, visually transparent training and production spaces*	*Sustainable mechanisms for knowledge transfer and reproduction of craft practices*
The individual and fragmented nature of production	*Modular workshops, common production areas*	*Cooperation between craftsmen and the formation of collective production processes*
Market instability and seasonality	*Transformable exhibition and retail spaces*	*Economic stability and adaptation to market changes*
The gap between education and practice	*Spatial integration of educational and production functions*	*Continuity of educational and production processes*
Fragmentation of social and professional ties	*Public spaces for interaction and exchange*	*Formation of communities of practice and social networks*
Variability in forms of employment and demand	*Flexible planning structure and temporary adaptability*	*Emergent spatial order and long-term stability*

Discussion

The results obtained allow us to consider the architecture of folk craft centres as a mechanism for forming a social space in which the dynamics of order and chaos take on a productive character. In this context, architecture is not an instrument of strict control, but an environment for coordinating diverse social, cultural and economic processes.

From the point of view of social theory, space is formed through practices and interactions. The integration of education, production and business within folk craft centres contributes to the formation of a special type of social space that ensures the sustainable reproduction of craft practices (Lefebvre, 1991). The identified architectural principles (Table 1) can be interpreted as spatial mechanisms for structuring interactions without losing their variability.

Folk craft centres combine different modes of activity — education, labour and commerce — in a single space, forming a hybrid environment in which formal and informal practices interact and transform each other. This nature of space allows us to consider these centres as heterotopias that provide a "switching of orders" within a single architectural structure (Foucault, 1967).

В контексте охраны нематериального культурного наследия важным является сохранение баланса между институциональной поддержкой и живым характером традиций. Архитектурные решения, ориентированные на гибкость и открытость, позволяют поддерживать адаптивность ремесленных практик и предотвращать их музеефикацию (UNESCO, 2003).

The economic dimension of folk craft centres is particularly relevant in the context of the development of creative industries. The architectural models under consideration can contribute to the integration of crafts into modern economic processes, reduce market uncertainty and strengthen cooperation at the local level (UNCTAD, 2024).

The Kazakh context highlights the practical significance of the results obtained. Government strategic documents note the need to develop cultural infrastructure and support traditional forms of creativity (President of the Republic of Kazakhstan, 2014), while empirical studies point to the vulnerability of craft practices in the context of the transformation of knowledge transfer mechanisms (Shaigozova, 2023). The architecture of folk craft centres can be seen as a link between cultural policy and the everyday practices of craftspeople.

Overall, the discussion of the results confirms that the architecture of folk craft centres can act as a mediator between order and chaos, creating conditions for an emergent socio-economic order that is applicable beyond a specific regional context.

Conclusion

The study showed that the architecture of folk craft centres can be seen as a mediating mechanism between chaotic socio-economic processes and the formation of a stable spatial order. In this context, architecture acts not as an instrument of strict regulation, but as an environment that structures the interaction of traditional craft practices with modern educational and economic systems.

A key condition for the sustainable development of folk crafts is the spatial integration of education, production and business. The identified architectural principles, based on flexibility, adaptability and functional connectivity, make it possible to support the transfer of knowledge, cooperation between masters and the economic viability of craft practices without losing their cultural diversity.

An examination of the Kazakhstani context confirmed the applicability of this model in a post-traditional society and revealed the potential of the architecture of folk craft centres as a tool for implementing cultural and socio-economic policies. The proposed principles can be used in the formation of similar hybrid spaces in other regions.

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Keywords: *architecture of craft centers, socio-economic integration, complexity in architecture, order and chaos, traditional crafts.*

Chemical sciences

CHEMICAL TRANSFORMATION PROCESSES IN CRUDE OIL REFINING: COMPOSITION DYNAMICS AND EFFICIENCY OF HYDROCARBON CONVERSION

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Crude oil represents a complex multicomponent system composed of hydrocarbons of varying molecular weight and structure, as well as heteroatomic compounds containing sulfur, nitrogen, oxygen, and trace metals. The chemical transformation of crude oil during refining is driven by the need to convert this heterogeneous raw material into valuable fractions with specific physicochemical properties suitable for industrial and energy applications. Understanding the dynamics of compositional change and the efficiency of hydrocarbon conversion processes is fundamental for optimizing refining operations and improving product yield.

The chemical composition of crude oil varies significantly depending on geological origin, maturity, and reservoir conditions. Light crudes are typically rich in low-molecular-weight paraffinic and naphthenic hydrocarbons, whereas heavy crudes contain higher proportions of resins and asphaltenes. These compositional differences determine the selection and performance of refining processes. Chemical transformation during refining aims to redistribute molecular structures through cracking, reforming, and treatment processes, enhancing the proportion of lighter, more valuable products.

Primary refining processes separate crude oil into fractions based on boiling range without altering molecular structure. However, the chemical value of crude oil is realized mainly through secondary processes that induce molecular transformation. Thermal and catalytic conversion processes modify hydrocarbon chains, breaking larger molecules into smaller ones or rearranging molecular structures to improve fuel quality. The efficiency of these processes depends on feedstock composition and reaction conditions.

Hydrocarbon conversion efficiency reflects the degree to which heavy and less valuable fractions are transformed into lighter products with higher economic value. From a chemical perspective, this efficiency is governed by reaction pathways, catalyst activity, and the distribution of reactive species within the feedstock. Crude oils with high resin and asphaltene content pose particular challenges due to their tendency to form coke and deactivate catalysts during processing.

The dynamics of compositional change during refining involve a continuous redistribution of molecular weight fractions. As cracking severity increases, long-chain hydrocarbons undergo bond cleavage, forming shorter chains and aromatic compounds. While this increases yields of gasoline and middle distillates, excessive severity can lead to undesirable by-products such as gases and coke. Therefore, balancing conversion intensity is essential for maintaining chemical efficiency.

Sulfur-containing compounds represent a critical aspect of crude oil chemistry. During refining, sulfur compounds are transformed or removed to meet product quality standards and environmental regulations. Chemical treatment processes reduce sulfur content by converting organosulfur compounds into removable forms. The distribution and chemical nature of sulfur compounds influence treatment efficiency and catalyst performance.

Nitrogen and oxygen compounds also affect refining chemistry by interacting with catalysts and influencing reaction pathways. These heteroatoms may inhibit catalytic activity or alter selectivity, reducing overall conversion efficiency. Effective chemical transformation strategies must account for the presence and behavior of these compounds.

Table 1 presents a generalized overview of major crude oil components and their behavior during chemical transformation processes.

Table 1. Major Crude Oil Components and Their Transformation Behavior

Crude oil component	Chemical characteristics	Behavior during refining
Paraffins	Saturated hydrocarbons	Crack into lighter alkanes
Naphthenes	Cycloalkanes	Rearranged or dehydrogenated
Aromatics	Stable ring structures	Concentrated or reformed
Resins	Polar, high-molecular compounds	Partially cracked, catalyst-sensitive
Asphaltenes	Highly complex structures	Coke formation tendency

Catalytic processes play a central role in hydrocarbon conversion efficiency. Catalysts facilitate selective bond breaking and rearrangement, enabling high yields under controlled conditions. The chemical interaction between catalyst surface and hydrocarbon molecules determines selectivity and reaction rate. Catalyst deactivation, caused by coke deposition and metal contamination, remains a significant challenge, particularly when processing heavy crude oils.

Chemical efficiency in refining is closely linked to reaction environment control. Temperature, pressure, and residence time influence reaction pathways and product distribution. Elevated temperatures enhance cracking reactions but also increase coke formation. Pressure affects phase behavior and hydrogen availability, influencing hydrogenation reactions. Optimizing these parameters is essential for achieving desired conversion outcomes.

Hydrogen balance represents another key chemical consideration. Hydrogen-consuming reactions stabilize cracked molecules and suppress coke formation. Feedstocks deficient in hydrogen require careful management to maintain conversion efficiency. Chemical strategies that improve hydrogen utilization enhance overall refining performance.

Table 2 summarizes key chemical factors influencing hydrocarbon conversion efficiency in refining processes.

Table 2. Chemical Factors Affecting Hydrocarbon Conversion Efficiency

Chemical factor	*Influence on conversion efficiency*	*Operational implication*
Feedstock composition	*Determines reaction pathways*	*Process selection and severity control*
Catalyst activity	*Controls selectivity and rate*	*Catalyst management required*
Reaction temperature	*Enhances molecular transformation*	*Risk of over-cracking*
Hydrogen availability	*Stabilizes reaction products*	*Reduced coke formation*
Heteroatom content	*Inhibits catalytic reactions*	*Additional treatment steps*

From a broader chemical perspective, refining efficiency must be evaluated in terms of molecular transformation effectiveness rather than solely volumetric yield. Converting complex hydrocarbon structures into stable, usable products requires an integrated understanding of crude oil chemistry and reaction mechanisms. Refining strategies that align feedstock characteristics with appropriate chemical processes achieve higher efficiency and reduced waste generation.

Environmental considerations increasingly influence chemical transformation strategies. Minimizing by-product formation and reducing emissions require cleaner conversion pathways and improved treatment processes. Chemical optimization contributes to environmental performance by reducing sulfur and nitrogen content and limiting coke formation.

In conclusion, chemical transformation processes in crude oil refining are governed by complex interactions between feedstock composition, reaction conditions, and catalytic behavior. The dynamics of hydrocarbon conversion determine both product yield and process efficiency. Understanding these chemical processes enables more effective refining strategies, particularly when processing diverse crude oil types. Enhancing conversion efficiency through chemical optimization supports economic performance, resource utilization, and environmental compliance in modern refining operations.

Keywords: *Crude oil chemistry; Hydrocarbon conversion; Refining processes; Chemical transformation; Catalyst efficiency; Petroleum chemistry*

Economic sciences

ECONOMIC RESILIENCE OF SMALL OPEN ECONOMIES: STRUCTURAL ADJUSTMENT AND PRODUCTIVITY DYNAMICS

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1. Introduction

Small open economies are distinguished by limited domestic markets, high dependence on international trade, and strong exposure to external economic fluctuations. These characteristics create both opportunities and vulnerabilities. On the one hand, openness facilitates access to global markets, technology, and investment. On the other hand, external shocks—such as demand volatility, supply disruptions, and price instability—can transmit rapidly into domestic economic systems. Under such conditions, economic resilience becomes a critical determinant of long-term stability and growth.

Economic resilience refers to the capacity of an economy to absorb shocks, adapt to changing conditions, and recover without sustained loss of productive potential. In small open economies, resilience is closely linked to structural adjustment and productivity dynamics. Structural adjustment enables the reallocation of resources toward more competitive activities, while productivity growth supports income stability and competitiveness. Understanding how these processes interact is essential for designing effective economic strategies.

2. Conceptual Framework of Economic Resilience

Economic resilience encompasses resistance, adaptation, and recovery. Resistance reflects the ability to withstand initial shocks, adaptation involves adjusting economic structures and behavior, and recovery refers to restoring or improving performance after disruption. For small open economies, adaptation is often the most critical dimension, as resistance capacity is limited by size and openness.

Structural adjustment represents a core adaptive mechanism. By reallocating labor and capital from declining sectors to expanding ones, economies can maintain overall performance despite external pressures. Productivity dynamics determine the effectiveness of this reallocation, as higher productivity activities generate greater value added and fiscal capacity.

Institutions, policies, and market flexibility shape resilience outcomes. Transparent governance, predictable regulations, and efficient public administration reduce uncertainty and facilitate adjustment. In small open economies, institutional effectiveness has a disproportionate impact on resilience due to limited margins for error.

3. Structural Adjustment in Small Open Economies

Structural adjustment involves changes in sectoral composition and production organization. In small open economies, specialization often reflects comparative advantage, but excessive concentration increases vulnerability to sector-specific shocks. Diversification within tradable sectors enhances resilience by spreading risk.

Adjustment processes are influenced by investment behavior and labor mobility. Capital flows toward sectors with higher expected returns, while labor mobility enables reallocation of human resources. However, adjustment may be constrained by skill mismatches, capital immobility, and institutional barriers.

Policy frameworks that support retraining, innovation, and entrepreneurship facilitate structural adjustment. Without supportive policies, adjustment may be slow or socially costly, undermining resilience.

4. Productivity Dynamics as a Resilience Mechanism

Productivity growth strengthens resilience by increasing output per unit of input, improving competitiveness, and expanding fiscal capacity. In small open economies, productivity gains compensate for scale limitations and enable participation in global value chains.

Productivity dynamics vary across sectors and firms. Export-oriented and knowledge-intensive activities typically exhibit higher productivity growth due to competitive pressure and innovation. Diffusion of productivity gains across the economy depends on labor mobility, supply chain integration, and institutional support.

Productivity stagnation undermines resilience by reducing income growth and increasing vulnerability to shocks. Therefore, productivity-enhancing policies are central to resilience strategies.

Table 1. Productivity Dynamics and Their Contribution to Economic Resilience

Productivity dimension	Mechanism of influence	Resilience outcome
Labor productivity growth	Higher output per worker	Income stability
Sectoral productivity gaps	Resource reallocation potential	Adaptive capacity
Innovation-driven gains	Competitive differentiation	External shock absorption
Productivity diffusion	Spillover effects across sectors	Broad-based resilience

5. Labor Markets and Adaptive Capacity

Labor market flexibility is essential for structural adjustment and productivity-driven resilience. Flexible employment arrangements and effective matching mechanisms support labor reallocation toward growing sectors. At the same time, excessive flexibility without social protection may increase vulnerability and inequality.

Human capital quality influences adaptability. Education systems that emphasize transferable skills and continuous learning enhance workforce responsiveness to change. In small open economies, rapid technological shifts require ongoing skill upgrading.

Migration patterns also affect labor market resilience. Outward migration of skilled workers may weaken adaptive capacity, while targeted policies can mitigate negative effects by encouraging skill retention and return migration.

6. Institutional and Policy Dimensions

Institutions shape the environment in which adjustment and productivity dynamics unfold. Regulatory clarity, efficient public services, and policy coherence reduce transaction costs and support long-term investment. In small open economies, institutional trust stabilizes expectations during periods of uncertainty.

Economic policy plays a coordinating role. Investment in infrastructure, innovation support, and education strengthens resilience by enhancing productivity and facilitating adjustment. Countercyclical fiscal measures can cushion shocks, but long-term resilience depends on structural measures rather than short-term stabilization alone.

Table 2. Policy Instruments Supporting Economic Resilience

Policy instrument	*Primary objective*	*Contribution to resilience*
Innovation support	*Enhance productivity*	*Competitive adaptability*
Labor market policies	*Facilitate reallocation*	*Faster adjustment*
Education and training	*Build adaptable skills*	*Long-term resilience*
Institutional reform	*Improve governance efficiency*	*Reduced adjustment costs*

7. External Integration and Vulnerability Management

External integration is both a source of growth and vulnerability for small open economies. Trade openness exposes economies to global demand fluctuations, while financial openness increases sensitivity to capital flows. Managing these vulnerabilities requires strategic diversification and risk management.

Participation in global value chains enhances productivity but may also transmit shocks. Strengthening domestic linkages and upgrading value-added activities increase resilience by reducing dependence on low-value segments.

Exchange rate flexibility and prudent fiscal management further support resilience by absorbing external shocks and maintaining macroeconomic stability.

8. Long-Term Implications for Sustainable Growth

Economic resilience contributes to sustainable growth by enabling economies to adapt without persistent loss of capacity. Structural adjustment and productivity growth support income convergence and social stability. In small open economies, resilience strategies must balance openness with domestic capacity building.

Long-term growth depends on the cumulative effect of adaptive responses to repeated shocks. Economies that institutionalize learning and flexibility are better positioned to sustain development in volatile environments.

9. Conclusion

Economic resilience in small open economies is fundamentally shaped by structural adjustment and productivity dynamics. The ability to reallocate resources efficiently and generate productivity gains determines how economies absorb and adapt to external shocks. Institutions and policies play a decisive role in facilitating these processes.

Small open economies cannot eliminate vulnerability, but they can manage it through coherent strategies that strengthen adaptive capacity. By integrating structural adjustment with productivity-enhancing policies, such economies can achieve resilient and sustainable growth despite persistent external uncertainty.

Keywords: *Economic resilience; Small open economies; Structural adjustment; Productivity dynamics; Economic policy; Adaptive capacity*

Medical sciences

CLINICAL AND LIFESTYLE DETERMINANTS OF EARLY FUNCTIONAL DISORDERS IN THE CARDIOVASCULAR SYSTEM

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Introduction

Cardiovascular disorders continue to represent one of the leading causes of morbidity and mortality worldwide, with a substantial proportion of cases developing gradually over extended periods. In many patients, functional disturbances of the cardiovascular system precede clinically diagnosed disease by several years. These early functional disorders often remain unnoticed in routine clinical practice, despite their prognostic significance. Identifying the clinical and lifestyle determinants of such early changes is essential for effective prevention and timely intervention.

Early cardiovascular dysfunction is characterized by subtle alterations in vascular tone, cardiac workload regulation, and autonomic balance rather than overt structural pathology. These changes are frequently reversible if detected early, making them a critical focus of preventive medicine. Lifestyle factors interact with individual clinical characteristics to influence the onset and progression of functional cardiovascular disturbances. Understanding these interactions provides a foundation for targeted prevention strategies.

Early Functional Disorders of the Cardiovascular System

Functional disorders of the cardiovascular system refer to deviations in physiological regulation that do not yet meet criteria for structural disease. Examples include elevated resting blood pressure within high-normal ranges, reduced vascular elasticity, and impaired heart rate variability. Such disturbances reflect early dysregulation of cardiovascular control mechanisms.

These functional changes often emerge in response to cumulative stressors rather than acute events. The cardiovascular system adapts continuously to metabolic demands, environmental influences, and behavioral patterns. When adaptive capacity is exceeded, regulatory mechanisms become less efficient, leading to functional impairment.

Early functional disorders are clinically significant because they increase vulnerability to subsequent pathological changes. Persistent functional dysregulation may progress to hypertension, ischemic heart disease, or other cardiovascular conditions if underlying determinants are not addressed.

Clinical Determinants of Early Cardiovascular Dysfunction

Clinical determinants influence individual susceptibility to early cardiovascular disturbances. Age-related changes in vascular compliance and autonomic regulation contribute to functional decline, even in the absence of overt disease. Family history of cardiovascular conditions further increases risk by reflecting genetic and shared environmental influences.

Metabolic factors such as increased body mass index, central adiposity, and impaired glucose regulation play a central role. These factors increase cardiac workload and promote endothelial dysfunction. Even modest deviations from optimal metabolic parameters may have measurable effects on cardiovascular function.

Blood pressure variability represents another important clinical determinant. Fluctuations within normotensive ranges may indicate early dysregulation of vascular control. Such variability often precedes sustained hypertension and is associated with increased cardiovascular risk.

Lifestyle Determinants and Behavioral Influences

Lifestyle factors exert a profound influence on cardiovascular function. Physical inactivity reduces cardiovascular fitness and impairs vascular responsiveness. Regular physical activity, by contrast, supports endothelial health, autonomic balance, and myocardial efficiency.

Dietary patterns influence cardiovascular function through effects on lipid metabolism, blood pressure regulation, and inflammatory processes. Diets high in saturated fats and sodium contribute to vascular stiffness and functional impairment, while balanced diets support cardiovascular adaptability.

Psychosocial stress represents a significant lifestyle determinant. Chronic stress activates neuroendocrine pathways that elevate heart rate and blood pressure, contributing to functional overload. Without effective coping mechanisms, stress-related cardiovascular responses may become maladaptive.

Sleep quality and duration also influence cardiovascular regulation. Sleep deprivation disrupts autonomic balance and increases sympathetic activity, contributing to functional disturbances. Adequate sleep supports cardiovascular recovery and resilience.

Interaction Between Clinical and Lifestyle Factors

Early functional cardiovascular disorders rarely result from isolated factors. Rather, they emerge from interactions between clinical predispositions and lifestyle behaviors. For example, individuals with genetic susceptibility may remain functionally stable until adverse lifestyle factors trigger dysregulation.

These interactions highlight the importance of integrated assessment. Evaluating lifestyle behaviors alongside clinical indicators enables more accurate risk identification. Preventive strategies that address both dimensions are more effective than approaches targeting single factors.

Clinical Assessment and Early Detection

Early detection of functional cardiovascular disorders requires careful clinical assessment beyond standard diagnostic thresholds. Resting blood pressure, heart rate variability, and functional capacity assessments provide insight into regulatory efficiency. These measures are accessible and cost-effective in primary care settings.

Lifestyle assessment complements clinical evaluation by identifying modifiable determinants. Structured interviews and questionnaires enhance the reliability of lifestyle data. Combining clinical and lifestyle information supports comprehensive risk profiling.

Table 1

Clinical and Lifestyle Determinants of Early Functional Cardiovascular Disorders

Determinant	*Associated Functional Change*	*Preventive Significance*
High-normal blood pressure	*Increased vascular load*	*Early hypertension risk*
Central adiposity	*Endothelial dysfunction*	*Metabolic and cardiovascular risk*
Physical inactivity	*Reduced cardiovascular adaptability*	*Lower functional reserve*
Chronic stress	*Autonomic imbalance*	*Increased cardiac workload*
Poor sleep quality	*Elevated sympathetic activity*	*Impaired recovery*

Preventive Strategies and Lifestyle Modification

Preventive strategies targeting early functional disorders emphasize lifestyle modification and risk factor management. Increasing physical activity improves vascular function and autonomic balance. Even moderate increases in activity yield measurable benefits.

Dietary interventions focus on reducing sodium intake, improving fat quality, and supporting metabolic health. Nutritional counseling tailored to individual preferences enhances adherence and effectiveness.

Stress management techniques, including behavioral interventions and lifestyle adjustments, reduce neuroendocrine activation and support cardiovascular regulation. Improving sleep hygiene further enhances preventive outcomes.

Role of Preventive Healthcare Systems

Preventive healthcare systems play a central role in addressing early cardiovascular dysfunction. Primary care settings provide opportunities for routine screening and longitudinal monitoring. Integrating functional assessment into regular health evaluations enhances early detection.

Public health initiatives that promote healthy lifestyles complement individual-level interventions. Population-wide strategies reduce the prevalence of risk factors and support cardiovascular health across communities.

Conclusion

Early functional disorders of the cardiovascular system represent a critical stage in the development of cardiovascular disease. These disorders are shaped by interactions between clinical determinants and lifestyle behaviors. Identifying and addressing these factors during the functional phase offers significant potential for disease prevention.

Comprehensive assessment and targeted lifestyle modification form the cornerstone of preventive strategies. By focusing on early functional changes rather than waiting for structural disease, healthcare systems can reduce cardiovascular burden and improve long-term population health outcomes.

Keywords: *Cardiovascular function; Early functional disorders; Lifestyle determinants; Preventive medicine; Clinical assessment; Cardiovascular risk*

Pedagogical sciences

PERSONALIZED LEARNING TRAJECTORIES AS A FACTOR OF ACADEMIC MOTIVATION IN HIGHER EDUCATION

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Personalized learning trajectories have become an increasingly significant concept in contemporary higher education, reflecting the growing recognition of student diversity in cognitive styles, prior knowledge, learning pace, and motivational orientation. Traditional standardized educational models often fail to address individual differences, resulting in reduced engagement and uneven learning outcomes. In contrast, personalized learning trajectories aim to align educational content, methods, and assessment with individual student needs, thereby enhancing academic motivation and overall educational effectiveness.

Academic motivation plays a central role in determining students' engagement, persistence, and achievement in higher education. Motivation influences how students perceive learning tasks, allocate effort, and respond to challenges. When learning experiences are perceived as relevant and attainable, students are more likely to demonstrate sustained interest and commitment. Personalized learning trajectories support this process by providing students with meaningful choices and a sense of ownership over their educational pathways.

The concept of a personalized learning trajectory involves the intentional design of flexible educational pathways that accommodate individual learning goals and capacities. Such trajectories may differ in content sequence, learning activities, and assessment formats while maintaining common educational standards. By allowing students to progress according to their abilities and interests, personalized approaches reduce cognitive overload and frustration, fostering a more positive learning experience.

Personalization contributes to motivation by enhancing perceived autonomy, which is a fundamental psychological need. When students have opportunities to make decisions about learning topics, methods, or pacing, they experience greater control over their education. This sense of autonomy strengthens intrinsic motivation and encourages deeper engagement with academic material. Personalized trajectories thus transform students from passive recipients of instruction into active participants in the learning process.

Another motivational mechanism associated with personalized learning is the enhancement of perceived competence. Learning trajectories that align with students' current skill levels enable achievable challenges and incremental progress. Experiencing success reinforces self-efficacy and motivates further effort. Conversely, mismatched instructional demands may undermine confidence and reduce motivation. Personalization helps calibrate challenge levels, supporting sustained engagement.

Personalized learning trajectories also support goal orientation by connecting academic activities with students' personal and professional aspirations. When students recognize the relevance of learning to their future goals, motivation increases. Personalized pathways facilitate this connection by allowing students to pursue topics and projects aligned with individual interests, thereby strengthening the perceived value of education.

The role of educators is critical in implementing personalized learning trajectories effectively. Instructors act as facilitators who guide students in setting goals, selecting learning strategies, and reflecting on progress. This guidance ensures that personalization does not result in fragmentation or loss of academic coherence. Effective pedagogical support balances flexibility with structure, maintaining academic rigor while accommodating individual differences.

Assessment practices within personalized learning environments influence motivation by reinforcing learning goals. Formative assessment and continuous feedback provide students with information about progress and areas for improvement. Personalized feedback supports self-regulation and encourages reflection, further strengthening motivation. Transparent assessment criteria ensure fairness and clarity across diverse learning pathways.

Social interaction remains an important component of personalized learning. While trajectories are individualized, collaborative activities and peer learning opportunities contribute to motivation and social engagement. Interaction with peers provides feedback, social support, and opportunities for shared learning, preventing isolation and enhancing the educational experience.

Challenges associated with personalized learning trajectories include increased demands on instructional design and assessment. Educators must manage diverse learning paths while ensuring consistency and quality. Institutional support and professional development are essential for addressing these challenges. Without adequate support, personalization efforts may be superficial or unevenly implemented.

Technological tools facilitate personalized learning by enabling flexible content delivery, progress tracking, and adaptive feedback. However, personalization is not solely dependent on technology. Pedagogical intent and instructional design remain central to effective implementation. Technology serves as a means rather than an end, supporting educational goals.

The impact of personalized learning trajectories on academic motivation extends beyond immediate engagement. Motivated students are more likely to develop lifelong learning skills and adaptive capacities. Personalization fosters self-awareness and responsibility for learning, preparing students for continuous professional development.

In conclusion, personalized learning trajectories represent a powerful factor in enhancing academic motivation in higher education. By supporting autonomy, competence, and goal alignment, personalization addresses key motivational needs and promotes sustained engagement. Effective implementation requires thoughtful pedagogical design, educator support, and institutional commitment. Integrating personalized learning trajectories into higher education contributes to improved motivation, learning outcomes, and student satisfaction, reinforcing the role of education as a transformative and individualized process.

Keywords: *Personalized learning; Academic motivation; Higher education; Learning trajectories; Student engagement; Pedagogical design*

Philological sciences

SPATİAL ADPOSİTİONS İN THREE-DİMENSİONAL CONTEXTS İN ENGLİSH: A COGNİTİVE LİNGUİSTİC PERSPECTİVE

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Abstract

Spatial adpositions such as in, on, over, under, and at encode complex three-dimensional (3D) relationships that structure how English speakers conceptualize space. This study explores the cognitive linguistic foundations of 3D spatial adpositions, drawing on insights from embodied cognition, psycholinguistics, and neuroscience. Spatial prepositions are shown to arise from recurring patterns of bodily experience, known as image schemas—mental structures representing containment, support, or proximity. Through these schemas, linguistic expressions of space reflect sensorimotor experience, contextual salience, and functional affordances. The paper integrates perspectives from cross-linguistic studies, neuroscience, and computational modeling, emphasizing how cognitive and neural mechanisms underpin spatial understanding. Furthermore, recent interdisciplinary research connects spatial semantics to artificial intelligence (AI) and robotics, highlighting the relevance of 3D spatial reasoning in multimodal large language models (MLLMs) and vision-language systems. The findings underscore that English spatial adpositions are conceptually grounded, systematically polysemous, and dynamically context-dependent—revealing how language encodes the human experience of perceiving and interacting within 3D environments.

Introduction

Spatial adpositions form a core component of English syntax and semantics, expressing spatial relations in both physical and abstract domains (Tyler & Evans, 2003). In three-dimensional (3D) contexts, these prepositions extend beyond simple geometric relations to encode viewpoint, function, and embodied experience (Kemmerer, 2006). Understanding 3D spatial adpositions contributes not only to linguistics but also to fields such as robotics, spatial reasoning, and cognitive psychology.

From the perspective of ***c****onceptual foundations of spatial adpositions, cognitive linguistics posits that spatial adpositions are grounded in embodied experience our physical interaction with a 3D environment shapes linguistic meaning (Lakoff & Johnson, 1980; Tyler & Evans, 2003). Adpositions do not merely describe geometry but construe relations of containment, support, and proximity (Brenda, 2014).*

For instance, in encodes a three-dimensional container schema, while on implies contact along a surface (Wang, 2020). The cognitive approach also highlights the polysemy networks of prepositions, where a central image schema generates metaphorical extensions (Zwarts, 2017).

According to conceptual foundations of spatial adpositions, cognitive linguistic framework, spatial adpositions such as in, on, under, above, at, near as essential linguistic tools for structuring how humans conceptualize spatial relations. In English and other languages, they function as linguistic realizations of image schemas, mental structures grounded in embodied perception and interaction (Tyler & Evans, 2003; Lakoff & Johnson, 1980).Recent SCOPUS-indexed research has shown that these adpositions are not arbitrary grammatical markers but conceptually motivated by sensorimotor experience, cognitive categorization, and contextual salience (Rashid, 2025; Brenda & Mazurkiewicz-Sokołowska, 2022).

The conceptual foundation of spatial adpositions lies in embodied cognition, the idea that spatial meaning derives from physical interaction with the world. According to Johnson (1987), humans develop recurring patterns of bodily experience, or image schemas, such as CONTAINMENT, SUPPORT, and PATH.

These schemas underlie the semantics of spatial adpositions:

- ***IN*** *reflects containment within bounded 3D regions.*
- ***ON*** *expresses support and contact with a surface.*
- ***OVER*** *encodes superposition and potential coverage in vertical orientation (Zwarts, 2017).*

Neuroscientific findings further support this embodiment: spatial prepositions activate parietal regions associated with visuospatial mapping (Kemmerer, 2006). Image Schema Theory (IST) provides a unified model linking linguistic and perceptual representations. It postulates that meaning construction is schematic, experiential, and dynamic (Evans & Green, 2006).

*A 2025 study by Rashid (Journal for Language and Education, Garmian University***)** *empirically validated IST-based teaching of prepositions, demonstrating improved comprehension when learners visualized 3D spatial schemas. This aligns with earlier work by Tyler & Evans (2003), who mapped in, on, and at as overlapping schemas structured by center-periphery relations and functional relevance.Dealing with conceptual metaphor and polysemy also explain why spatial adpositions exhibit polysemy multiple related senses derived from a central schema (Brenda, 2014).For example, in extends metaphorically from spatial containment (in the box) to abstract domains (in love, in trouble). These metaphorical extensions are not arbitrary but governed by embodied conceptualization (Lakoff & Johnson, 1980; Tyler & Evans, 2003).This systematic network of meanings often represented as radial categories shows how cognitive models unify physical and abstract uses (Zwarts, 2017).*

Some linguists argue cross-linguistic studies reveal that while the conceptual foundations of spatial adpositions are universal, their linguistic encoding varies. Levinson & Meira (2003) showed that spatial partitioning differs across languages depending on topological salience. English emphasizes support and containment, while other languages foreground orientation and contact.Cultural cognition thus shapes how speakers map 3D space linguistically (Tenbrink, 2005). These insights underscore the universality of embodied conceptualization but the variability of linguistic realization.

In modern linguistics contextual and functional dynamic spatial adpositions are contextually dynamic meaning shifts with functional relations between objects (Brala, 2000). The cup on the table and the fly on the table both encode support,

yet differ in spatial precision and functional relevance. The conceptual foundation here lies in functional affordances: spatial meaning depends not only on geometry but on pragmatic interpretation and object interaction (Evans, 2010).

In pedagogical and applied implications the conceptual framework for spatial adpositions informs both language teaching and computational modeling. Linguist Rashid (2025) demonstrated that schema-based visualization significantly improves preposition acquisition among EFL learners.In NLP, 3D spatial semantics aids in robot navigation and scene description generation (Kemmerer, 2006). Conceptual modeling thus bridges linguistic theory with applied technology. The conceptual foundations of spatial adpositions in English are deeply rooted in embodied cognition, image schemas, and conceptual metaphor. They reveal how linguistic expressions of space emerge from human perceptual and motor experience, organized through schematic mental structures that extend into abstract reasoning. This understanding strengthens both cognitive linguistic theory and its pedagogical and computational applications.

Spatial language operates within a mental model of three-dimensional space (O'Keefe, 1996). The prepositions under, above, behind, and in front of require reference to 3D axes height, depth, and orientation (Levinson & Meira, 2003).

Kemmerer (2006) demonstrated that brain regions encoding spatial prepositions overlap with those responsible for spatial navigation, reinforcing the link between linguistic and perceptual representations. Moreover, Tenbrink (2005) emphasized that dimensional prepositions differ cross-linguistically in how they partition 3D space (e.g., under vs. below). Three-Dimensional Spatial Semantics: An Emerging Intersection of Cognition, Language, and Artificial Intelligence (3D) refers to the study of how meaning is constructed, represented, and processed in three-dimensional space bridging cognitive linguistics, computer vision, and virtual spatial reasoning. It explores how humans and machines conceptualize relations like above, inside, or across when extended into volumetric and dynamic environments (Herskovits, 1997). This interdisciplinary field has gained traction due to advances in multimodal large language models (MLLMs), virtual reality, and robotic spatial cognition (Liu et al., 2025).

From a cognitive linguistics standpoint, spatial semantics investigates how linguistic expressions encode perceptual experiences of 3D environments. Early work by Herskovits (1997) linked spatial prepositions to geometric schemas and perceptual grounding. Contemporary studies argue that spatial semantics underpin embodied cognition, influencing how humans interpret scenes and navigate virtual environments (Guo et al., 2025).

Moreover, Xu et al. (2025) emphasize that spatial cognition integrates sensory perception with semantic categorization, aligning language with spatial awareness. This explains why large language models with 3D grounding outperform text-only models in spatial reasoning tasks. Based on computational modelling and vision vntegration modern research extends 3D spatial semantics into AI and computer vision. Visual-language models (VLMs) now integrate semantic scene reconstruction, enabling machines to interpret 3D environments with linguistic understanding (Meng, Zhou, & Chen, 2024). For instance, Scene-LLM (Fu et al., 2025) fuses vision and language features to perform spatial reasoning, object recognition, and scene alignment.

Similarly, multimodal benchmarks like spatial bench test models on spatial cognition using both visual and textual inputs (Xu et al., 2025). These approaches are key in robotics and virtual simulation systems where perception and action depend on spatial semantic understanding (Mehta, Sharma, & Thiyagarajan, 2025).

İn addition emerging applications and challenges of 3D spatial semantics span robotic navigation, AR/VR environments, urban modeling, and spatial narrative visualization. Guo et al. (2025) introduced semantic-driven 3D visualization frameworks for geographic storytelling, demonstrating how text-to-3D mapping enhances comprehension in virtual spaces.

However, challenges remain in aligning symbolic reasoning with perceptual data. Ma et al. (2024) highlight limitations in how MLLMs handle occlusion, rotation, and perspective issues inherent to 3D cognition. Moreover, ethical considerations in autonomous systems require semantic transparency for safe spatial decision-making (Monjoree & Yan, 2024).

On the whole, three-dimensional spatial semantics represents a frontier in human-AI interaction, combining language understanding, spatial reasoning, and machine perception. Future work should aim for deeper neural-symbolic integration, allowing AI systems to navigate and describe complex spatial environments with human-like semantic precision.

We also distinguish cognitive models of 3D reference, namely the vector grammar theory (O'Keefe, 1996) models spatial prepositions as vectors connecting entities in 3D. This geometric account complements the conceptual integration model, in which prepositions are schematic constraints applied to mental scenes (Tyler & Evans, 2003).

Zwarts (2017) formalized spatial semantics using 3D coordinate geometry, enabling logical modeling of expressions like The lamp is above the table. However, cognitive linguists argue that geometry alone cannot explain contextual variation meaning depends on function, interaction, and affordances (Song, 2013).

Conclusion

*Spatial adpositions in English provide a window into how humans conceptualize three-dimensional space through language. Rooted in **embodied cognition**, they reflect sensorimotor experience and conceptual metaphor, structuring both concrete and abstract thought. Cognitive linguistic frameworks—especially Image Schema Theory—demonstrate that meaning construction is experiential, schematic, and context-sensitive. Cross-linguistic and neuroscientific evidence corroborate this embodied foundation, while computational models extend these insights into 3D spatial reasoning for AI systems. The convergence of cognitive linguistics, neuroscience, and artificial intelligence thus marks a transformative stage in understanding spatial semantics—revealing how language, thought, and perception co-construct our sense of space in both human and artificial cognition.*

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Political sciences

CONCEPTS OF LEGAL AND POLITICAL SUBJECTIVITY STATE SOVEREIGNTY AND INTERSTATE COOPERATION

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SUMMARY

Recognizing the state as an independent, supreme actor, possessing exclusive authority within its territory and the right to self-determination abroad (sovereignty), while simultaneously recognizing the need for voluntary cooperation with other states to resolve common problems, transforms absolute power into responsibility and leads to a narrowing of sovereignty in the context of international law and globalization, while maintaining its key role. Therefore, the problem of balancing state autonomy and international cooperation forces many states to choose a "golden mean."

The legal concept of sovereignty is the exclusive right of a state to establish and exercise authority within its territory and independence in international affairs. It is enshrined in the Constitution and international law, which proclaims its

- exclusive jurisdiction: the state itself establishes laws and implements them within its territory;

- primary subjectivity: sovereignty as an inherent quality of the state, recognized by international law (UN Charter) [3];

- constitutional enshrinement: includes guarantees of the rights and freedoms of citizens, as well as the supremacy of the Constitution within the country.

The political concept emphasizes the genuine autonomy of the government, its ability to pursue independent policies based on the will of the people, and to act as an independent entity on the global stage. It is based on:

- independent and sovereign will: the ability to make decisions in foreign and domestic policy without external pressure;

- the exercise of power: based on political will, strategic interests, and national priorities;

- diplomatic independence: the state acts in its own interests on the international stage, strengthening its status;

- the philosophy of statehood: sovereignty is the foundation of independence and national philosophy, confirming the status of the state. [1]

Legal and political concepts that will be formulated in the future:

- legal sovereignty provides the legal basis for political independence;

- the political implementation of sovereignty (independent policy) gives it legal significance and international recognition.

- the constitution and sovereignty represent the two pillars that ensure legal stability (the constitution) and political independence (sovereignty).

At various stages of historical development, the phenomenon of state power has not changed its political and legal essence; it has remained and remains the supreme and independent political authority. The attribution of sovereignty as the highest political authority to the dominant subject presupposes a structural construction of the political system of society in which the place of other subjects relative to the sovereign is clearly defined. This stems from the principle of the indivisibility of sovereignty. [2]

An analysis of the dynamics and periodicity of changes in forms of sovereignty shows that a given form is always replaced by an alternative. At various stages of historical development, priority was given to the interests of either the state, society (the people), or the individual.

Thus, socio-political development itself appears to be a variable shift in forms of sovereignty.

The search for a middle ground between the primacy of power within a country and the need to interact with other states is realized through a balance between state autonomy (sovereignty) and international cooperation. This can be achieved through participation in international treaties and organizations, and compliance with international law. While this limits absolute autonomy to some extent, it provides advantages in addressing global issues, trade, and security.

The essence of this balance is that a state voluntarily accepts obligations, reducing its independence for the benefit of cooperation with organizations such as the UN, WTO, or EU.

Key aspects of balance are based on:

- sovereignty – the independence of the state in domestic and foreign policy, the supremacy of its authority within its territory;

- international cooperation: interacting with other countries and organizations to address common problems – environmental, trade, security;

- voluntary limitations: accession to international treaties (for example, on human rights) and trade agreements (voluntarily limiting sovereignty, but ensuring predictability and mutual benefit);

- a legal environment, where states integrate into the international legal system, where their internal legal autonomy is correlated with international norms, which requires compromise.

Examples of this balance include:

The United States: a constant dialogue between the principle of the rule of national laws (internal autonomy) and the need to participate in global alliances (the UN, NATO, and the WTO), where the United States voluntarily accepts obligations in exchange for collective benefits but retains the right to veto or withdraw, determining its level of participation based on national interests and political consensus. This balance manifests itself in disputes over trade, security, and international agreements, where the desire for independence (isolationism) competes with the recognition of interdependence. It can be said that the balance in the United States is not static, but is determined by the administration's policies and public opinion, oscillating between isolationism and active international leadership.

China: Beijing resolutely defends its sovereignty, particularly in matters of "core interests," but actively participates in international economic and integration cooperation (such as

the Belt and Road Initiative and the SCO). Beijing seeks an equal partnership where its economic power is combined with strategic autonomy, rather than blind adherence to Western standards. It seeks the benefits of globalization while maintaining control over domestic policy, refusing to succumb to pressure on human rights or labor conditions, which often causes friction with the West.

Türkiye: Seeking "strategic autonomy," balancing the interests of the West (NATO) and Russia, it strives for a balance between sovereignty and cooperation. Turkey is actively expanding its influence as a regional leader and mediator, while maintaining independence, for example, in relations with Russia, the EU, and the US. It utilizes its geostrategic position for a multi-vector policy and defends national interests, as evidenced by its active participation in regional organizations and initiatives, as well as its desire for greater independence in security matters.

Russia: Uses its status as a great power to advance a multipolar world order while simultaneously pursuing absolute sovereignty in its immediate region. In doing so, Russia often clashes with Western liberal values, emphasizing traditionalism, self-determination, and strategic autonomy to counter perceived Western hegemony. This includes selective cooperation (e.g., BRICS, SCO) and unilateral actions (e.g., Ukraine, Georgia) to achieve goals such as technological independence and influence, sometimes undermining the international norms it claims to uphold.

Azerbaijan: The balance between sovereignty and international cooperation is built on strengthening national independence through active participation in global politics, diversifying partnerships (with the West, Turkey, China, and the UAE), and promoting its role in energy security and regional projects. At the same time, Azerbaijan is centralizing domestic power, as exemplified by the reform of autonomous regions, strengthening control over regions, including Nakhchivan, and defending its interests in international organizations, emphasizing sovereignty and territorial integrity, as evidenced by its membership in the UN and other international organizations. Azerbaijan strives to be a strong, independent player on the global stage, actively cooperating with all parties to advance its national interests while firmly defending its sovereignty, particularly in matters of territorial integrity.

The main challenges in finding balance are:

How to maintain optimal engagement without losing independence or becoming isolated;

Potential conflicts between national interests and international obligations;

The balance is constantly shifting depending on the global situation, political priorities, and the development of the international system.

To overcome the difficulties in achieving a balance between state autonomy and international cooperation, it is necessary to adopt a pragmatic approach (voluntary transfer of some powers to international organizations in exchange for benefits), where sovereignty is viewed not as absolute isolation, but as the ability to make sovereign decisions, including on cooperation, based on national interests, adhering to the principle of sovereign equality and participating in multilateral agreements to solve global problems (climate, security, trade).

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***Keywords**: legal concept, political concept, state autonomy, international cooperation, difficulties, "golden mean".*

GEOPOLITICAL SITUATION IN THE SOUTH CAUCASUS IN THE POST-CONFLICT PERIOD IN THE CONTEXT OF THE POSITIONS OF REGIONAL ACTORS

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Introduction. The 44th Day War in 2020 fundamentally changed the geopolitical landscape. With Azerbaijan's victory, the regional balance of power has also changed, and the potential for regional cooperation has increased, while the role of external players has changed. Azerbaijan gained political and military domination, Armenia's power and influence declined sharply, and Georgia was in danger of being sidelined if Azerbaijan and Armenia managed to sign a peace agreement. Russia brokered a ceasefire and increased the presence of military peacekeepers, while Turkey implemented a powerful political return to the region and a military presence in Azerbaijan.

The new situation has set the stage for opening up the region and expanding regional and international links through new or reopening transport corridors, railways and energy projects. Trade and transport are the most likely areas of cooperation between countries in the region and can be pursued simultaneously with or independently of the peace process between Azerbaijan and Armenia. The war and truce mediated by Russia have dealt a significant blow to European and American initiatives for conflict resolution in the format of the OSCE Minsk Group. Although the West has stressed its willingness to contribute, the various actors needed more trust in order to address the complex security issues in the region.

The purpose of the article is to analyze the new situation that paved the way for the opening of the South Caucasus region in expanding regional and international ties through new or reopening transport corridors, railways and energy transportation projects. A long history of conflict in the region and Russian dominance mean that there are serious concerns in all countries that Russia's influence may now increase. In general, the room for maneuver of external players has increased. The author concludes that although any changes in geopolitical calculations in the recent history of the South Caucasus have brought problems to both regional countries and nearby countries, the region is currently ready to influence the situation to ensure the security and stability of the EU and Europe as a whole. Consequently, regional countries, as well as European countries, should be more cautious than usual in their geopolitical choices.

Methods. The article widely uses such general scientific methods as analysis of historical chronicle, content-analysis of international documents, comparative analysis of situational processes, method of description of events.

Results. Certain conclusions are drawn on the main issues considered in the article. Attention is drawn to forecasts that can strengthen the geopolitical influence of regional and global actors in the South Caucasus, including such as ensuring security, removing trade barriers, as well as regional cooperation through the opening of new transport corridors.

With the Russian invasion of Ukraine, the regional situation has become even more fragile, adding new risks to a volatile security environment. Georgia, Armenia, and Azerbaijan initially tried to connect with the Western bloc while trying to avoid Russian attention. The long history of conflicts in the region and Russia's dominance mean that there are serious fears in all countries that Russia's influence could now increase. However, there is also the possibility that Russia's actions in Ukraine and changes in the international order could change historical patterns of behavior, which could at best lead to regional unification against a common threat. All countries may see the need to reduce the effects of Russian pressure and protect their national sovereignty, territorial integrity, and independence.

The war in Ukraine could be a catalyst for peace talks between Armenia and Azerbaijan. There is cautious optimism, but also concern about how Russia will act. Overall, the room for manoeuvre of external players has increased. There is an understanding of the changing regional balance of power between Russia and Turkey, among regional powers, and in relation to external forces. Turkey could strengthen its position in the region and become a challenge to Russian domination. However, this would require a restructuring of its Russian policy. In the present circumstances, regional countries would certainly benefit from a suitable forum to discuss the current situation and possible future with external powers.

The Caucasus is located between the Black and Caspian Seas and includes Georgia, Azerbaijan and Armenia, although geographically it can also include parts of Russia, Turkey and Iran. The Caucasus Mountains, where Europe and Asia converge, divide the Northern Caucasus, part of Russia and the Southern Caucasus of three independent Caucasian countries. From the Russian point of view, the last in history was called the Caucasus, which means the region «beyond the Caucasian mountains». The Great Caucasus divide is traditionally considered to be the point of separation between Europe and Asia. Therefore, while some analysts place the western part of the Caucasus region in Europe and the eastern part (most of Azerbaijan and small parts of Armenia, Georgia and the Caspian coast of Russia) in Asia, others define the Arax River as Turkey's border as a continental demarcation line that represents Armenia, Azerbaijan and Georgia in Europe.

The history of the Caucasus is a history of centuries of constant movement in the region. The region lies geostrategically along roads connecting north to south and east to west. Leaving aside the region's earlier history, the northern Caucasus has been defined by its resistance to Russian attacks and attempts to subjugate its people since the early 19th century. The south also witnessed foreign invasions and power struggles between the Russian, Ottoman and Persian states until the end of World War I. Direct Soviet control over the South Caucasus ended with the dissolution of the Union in December 1991, and Azerbaijan, Armenia, and Georgia finally became independent countries. However, the North Caucasus remains part of the Russian Federation, and since then various territorial disputes have arisen, allowing Russia to exert its influence in the region.

The Georgian-Russian war of August 2008 had a huge impact on regional geopolitics, because the countries of the region realized how far Russia would go in its supposed interests in the region and the failure of other players to prevent such an outcome. Moreover, the US withdrawal from the region,

which showed growing military/security interests after the September 11 attacks, has also played a role. Finally, Turkey reoriented its foreign policy towards the Middle East in the early 2000s after providing for the construction of the Baku-Tbilisi-Ceyhan (BTC) and Baku-Tbilisi-Erzurum (BE) pipelines. The expectation that cooperation with Russia in various neighboring geographical areas would yield better results than competition with it was no less important for this outcome. Similarly, the EU's internal problems and declining interest in the region after the region's energy resources were partitioned played a crucial role in strengthening the influence of the Russian Federation, which developed its relations with Azerbaijan and expanded its influence on Armenia.

The Second Karabakh War has once again shown that the region's geopolitics continue to develop. This time, we have seen the return of Turkey, the marginalization of Iran, a further weakening of the role of the West, including the Organization for Security and Cooperation in Europe (OSCE), and the emergence of Russian-Turkish partnership and competition over the future of the South Caucasus.

The Russian invasion of Ukraine on February 24, 2022 has again abruptly and instantly changed the already delicate geopolitical landscape. Since this is seen as a dissatisfaction of the Russian leadership with any degree of «sovereign choice» among its neighbors, it is perceived as a serious security problem for the states of the South Caucasus.

Russia's primary goal in the region was to position itself as a dominant military and power actor, and avoid Western powers such as the US and the EU. With the deployment of 2,000 Russian peacekeepers in Karabakh, Russia had troops in all three states of the South Caucasus. With the withdrawal of Armenian troops from Karabakh, Russia became the de facto patron in this area. It introduced Russian as a second language in the region. Russia was not only militarily present in Karabakh, but also manages a military base of almost 3,000 troops in Gyumri (Armenia). In addition, Russia protects Armenia's borders with Turkey and Iran, provided a transit route between Armenia and Nagorno-Karabakh, and according to the Tripartite Statement of 9/10 November 2020 was to play a decisive role in the future corridor into Nakhichevan from Azerbaijan through Armenia.

Although Russia has lost its most significant leverage over Azerbaijan, namely the unresolved Nagorno-Karabakh conflict, it has retained part of its influence by deploying Russian peacekeepers on Azerbaijani territory in 2020 (recently removed from the Karabakh region until the end of their planned presence until November 2025). Moreover, in the post-war environment, Russia has strengthened its position as a leading security actor in the Southern Caucasus through its exceptional mediation in the ceasefire and deployment of «peacekeeping forces» without an international mandate. But Russia is challenged by Turkey, Iran and China, especially in economic and transport matters. Moscow is «delaying» negotiations on a final settlement of the conflict, which may be its policy to benefit from conflicts rather than their solutions. However, as noted by Stefan Myster, this «(...) can only work as long as Russia has sufficient resources to support military force».

As a victorious player after the war, Azerbaijan has increased its power in the region. Not only at the cost of being able to change the facts on the ground, but also because he psychologically overcame his long humiliation from defeat in the First Nagorno-Karabakh War and occupation of his territory by his historical opponent in the early 1990s. In addition to the return of territory lost in the First Nagorno-Karabakh War, Azerbaijan has already invested US$3 billion in liberated areas, construction of infrastructure and housing with the intention of future resettlement of 700,000 internally displaced persons (IDPs), who had to leave their homeland in the early 1990s. Moreover, he will no doubt continue to benefit from the close security relationship that he has established with Turkey and Israel in the run-up to war. Finally, any economic cooperation and the possibility of connecting his Nakhchivan exclave through Armenia will eventually connect Turkey with Central Asia and China through Azerbaijan and the Caspian Sea, which will make it an important link for the Chinese initiative «One belt, one way».

Georgia was alarmed that Russia has increased its military presence in the South Caucasus, and worried about Georgia's continued isolation, especially if the warring countries can move forward with bilateral cooperation. The post-war problems for Georgia are mainly in the economic sphere, primarily as consequences of future transport routes that may challenge Georgia's position as an important regional transit country.

In the last war, Armenia lost the territory it had controlled since the early 1990s, and as such is seen by many as a clear loser. But the country could turn this into a positive sum if it were able to overcome domestic opposition from Nagorno-Karabakh Armenians and ultra-nationalists and gain support for further liberalization, democratization, and normalization of its relations with Turkey and Azerbaijan. This would undoubtedly put an end to its hitherto isolated position in the region, creating and strengthening its links with other regional countries and Europe. In turn, this would weaken its dependence on Russia, thereby strengthening its sovereignty and independence. Such a development would also help the economy of Armenia. However, much of this depends on the development of Armenia's domestic policy.

Like Russia, Turkey has strengthened its presence in the region, but so far has not been able to challenge Moscow's hegemonic position. Turkey's close relations with Azerbaijan, reflected in the unique place it received in the Shusha declaration of 15 June 2021 between the two countries, together with its restored military presence in the region after more than a century, make it stronger for the future, Especially after Russia withdrew its peacekeeping forces from the region. If successful, the process of normalizing relations between Armenia and Turkey will also strengthen Turkey's position in the region by establishing additional land ties between Azerbaijan and Nakhichevan. It further implements Turkey's long-term goal of gaining direct access to the Caspian Sea and beyond, bypassing Iran, and turning this region into a trans-shipment and transit hub for Europe. Moreover, Turkey is ready to benefit from the restoration of liberated territories of Azerbaijan and the success of Turkish production drones and other military systems used in Azerbaijan's war against armed Russia Armenia.

The Second Karabakh War has further diminished Iran's role in the region. Although it is the only country that has relations with Georgia, Azerbaijan and Armenia, it did not participate in war or settlement. Iran cannot compete with Turkey and Russia in the post-war environment for security, political influence, or economic leverage. Unlike Turkey and Israel, Azerbaijan did not invite him to restore the areas bordering Iran because of its strained relations with Azerbaijan. Iran has taken a seemingly pro-Armenian stance for many years, despite not being involved in the conflict. Fear of possible temptations by Iranian citizens of Azerbaijani and Turkic origin created a tense atmosphere. In addition, and this is particularly problematic for Tehran, the military cooperation between Israel and Azerbaijan has led to a strong condemnation by Iran

and an even harsher reaction by Azerbaijan. According to Iran, the victory of Azerbaijan is a geopolitical siege operation by Turkey and Israel against Tehran. In this context, Tehran does not want Azerbaijan's victory to be transformed into new geopolitical and strategic opportunities and realities. He is trying to obstruct Azerbaijan's regional initiatives by portraying them as an existential threat. Iran's categorical opposition to the Zanzibar corridor is an expression of its disagreement with any geopolitical and strategic changes aimed at Azerbaijan in the region.

Over the past decade, regional powers and the security environment created by the interaction between Russia and Turkey have increasingly focused on security-related issues.

As the post-war geopolitical changes have somewhat opened up the region, the most likely future changes will be experienced in its regional and international connectivity. The result of Russia's invasion of Ukraine may have further consequences for the degree and extent of interregional ties, and may affect the likelihood of implementation of various options. Some of the already discussed alternatives in transport corridors, rail links and energy supply routes are summarized below:

- Corridor «North-South»: International transport corridor «North-South», a planned railway route running from Finland through Russia to the Persian Gulf and India.

-Middle Corridor: A freight route between China, Central Asia, Turkey and the European Union through the South Caucasus.

- East-West corridor: a transit route conceived at the end of the Cold War, through which energy and other goods will be transported between Europe and Central Asia, passing through the Caspian Sea, Caucasus and Turkey, eventually connecting with China in the east and Pakistan and India in the south.

- China's «One belt, one way» initiative: including the economic corridor «China - Central Asia - Western Asia», which runs through the South Caucasus, although Beijing has not yet invested in significant infrastructure or transport projects. He has allocated significant funds to transit infrastructure, digital infrastructure and other projects in Azerbaijan, Armenia and Georgia.

-Zangezur corridor: the connection of Nakhichevan with Azerbaijan through the territory of Armenia involves disputes about who will control the route. While Azerbaijan insisted (2021) on the control of the route and pointed to the Lachin corridor that connects Armenia with the Karabakh region through the territory of Azerbaijan, Armenia categorically opposes any control of Azerbaijan in its territory, Allowing this to lead to further claims in the long run.

-Araks Railway Line: A major rail link between Azerbaijan and Armenia, built between 1899 and 1940 but damaged and subsequently destroyed during and after the First Nagorno-Karabakh War. In February 2021, Azerbaijan announced that it had started the reconstruction of the line on its territory. The implementation of this project will place the region at the centre of the future Black Sea-Persian Gulf rail link.

- Gyumri-Kars Railway: A direct connection between Armenia and Turkey will facilitate trade between the two countries, as well as between Nakhichevan and Turkey, and benefit Azerbaijan, Iran and Russia.

If the rail link to Araks is implemented, Iran may have to postpone the costly Astara-Resht line project and instead use the existing rail network through Julf across the border with Nakhchivan to connect further to the Azeri and Armenian lines.

- Baku-Tbilisi-Kars Railway (BTK): a large-scale project that started in 2017 and connects Turkey, Georgia, Azerbaijan as well as Europe with Central Asia and China.

- Baku-Tbilisi-Ceyhan oil pipeline (BTC): in operation since 2006. This pipeline transports oil from Azerbaijan through Georgia to Turkey and then across the Mediterranean to Europe.

- The Baku-Tbilisi-Erzurum (BE) gas pipelines run parallel to the BTC and transport natural gas mainly to Georgia and Turkey. It has the potential to supply Caspian gas to Europe through the planned southern gas corridor, as well as to transport gas from Turkmenistan and Kazakhstan.

- Trans-Anatolian Pipeline (TANAP): The section of the Southern Gas Corridor, commissioned in 2020. It transports gas from the Caspian Sea through Turkey to Europe.

- Baku-Supsa oil pipeline runs from the Sangachal terminal near Baku to the Supsa terminal in Georgia. It transports oil from the Azeri-Chiragh Gunnesli field and is operated by British Petroleum (BP). The history of this pipeline was troubled; the Russian invasion of Georgia allowed Russia to take control of a short section of the pipeline, and there were several spills and thefts. Although there is potential for expansion, there are currently no plans.

- Trans-Caspian Gas Pipeline (proposed) is a pipeline that transports gas from Turkmenistan to Azerbaijan via the Caspian Sea through an underwater pipeline. It is also known as the South Caucasus Pipeline Future Expansion (SCPFE) due to its connection with the South Caucasus Gas Pipeline.

Conclusion

Thus, the South Caucasus is once again in a state of geopolitical change. After the recent upheavals, these changes may prove stronger than any since the end of the Cold War. Although any changes in geopolitical calculations in the recent history of the Caucasus have brought problems for both regional countries and neighbouring countries, the region is now ready to influence the situation further as far as the security and stability of the EU and Europe are concerned. Therefore, regional countries, as well as European countries, should be more cautious than usual in their political choices.

Sustainable mechanisms for developing and promoting conflict resolution and peacebuilding should be established with the support and experience of regional countries. In this context, development of a humanitarian action plan for the return of displaced persons to the Karabakh region, assistance in the demining process in the border areas of the Karabagh economic zone, establishment of a platform for dialogue between expert communities from Armenia and Azerbaijan, Support of social interactions between Georgians, Abkhazians and Ossetians, provision of technical and financial support to negotiations are some of the possible alternative ways of participation of the civil community of the three South Caucasian states.

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Technical sciences

OPERATIONAL STABILITY AND RELIABILITY OF INDUSTRIAL TECHNICAL SYSTEMS UNDER NON-STATIONARY CONDITIONS

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Industrial technical systems increasingly operate under non-stationary conditions characterized by fluctuating loads, variable environmental influences, and evolving operational requirements. Such conditions challenge traditional engineering assumptions based on steady-state operation and predictable system behavior. Operational stability and reliability become critical performance attributes that determine system efficiency, safety, and economic viability. Ensuring these attributes under non-stationary conditions requires an integrated engineering approach that accounts for dynamic interactions among system components and external influences.

Non-stationary operating regimes arise from multiple sources, including demand variability, process reconfiguration, and gradual component degradation. These factors introduce uncertainty and stress that can compromise system stability and accelerate failure processes. Understanding how industrial systems respond to non-stationary conditions is essential for developing strategies that maintain reliable operation while optimizing performance.

Non-stationary conditions refer to operating environments in which system parameters vary over time rather than remaining constant. Load fluctuations, intermittent operation, and transient disturbances represent common forms of non-stationarity in industrial systems. These variations influence mechanical stress, thermal regimes, and control system behavior.

The frequency and amplitude of parameter changes affect system response. Rapid transitions may induce transient instability, while prolonged deviations alter operating points and stress distributions. Engineering analysis must therefore address both short-term dynamics and long-term effects of non-stationary operation.

Non-stationarity also complicates performance assessment, as average operating metrics may mask transient overloads or localized degradation. Reliable system evaluation requires continuous monitoring and dynamic analysis rather than static performance indicators.

Operational stability describes the ability of a system to maintain controlled and predictable behavior despite disturbances and variability. In non-stationary environments, stability depends on system robustness and adaptive capacity. Poorly matched subsystem dynamics or inadequate control strategies increase sensitivity to disturbances.

Stability-oriented engineering emphasizes design features that limit error propagation and enhance damping of oscillatory behavior. Modular architectures and balanced subsystem interaction contribute to stability by reducing interdependence and allowing localized disturbances to be isolated.

Control system design plays a central role in stability management. Feedback mechanisms regulate system behavior by compensating for deviations, but fixed-parameter control may be insufficient under non-stationary conditions. Adaptive control strategies adjust parameters in response to changing system dynamics, supporting stable operation across a wider range of conditions.

Reliability refers to the probability that a system performs its intended function without failure over a specified period. Under non-stationary conditions, reliability becomes a dynamic attribute influenced by variable stress and cumulative degradation. Components exposed to fluctuating loads experience accelerated fatigue and wear, increasing failure probability.

Non-stationary operation often leads to uneven component degradation, complicating maintenance planning. Reliability management must therefore focus on early detection of degradation patterns and proactive intervention. Condition-based maintenance aligns maintenance activities with actual system health rather than fixed schedules.

Human factors also affect reliability under dynamic conditions. Operator response to variability and adherence to procedures influence system behavior. Training and decision-support tools enhance human reliability and reduce the likelihood of operational errors.

Continuous monitoring is essential for maintaining stability and reliability in non-stationary environments. Sensors collect data on system states, loads, temperatures, and vibration levels, providing real-time insight into system behavior. Monitoring systems enable early detection of anomalies that may signal emerging instability or degradation.

Diagnostic analysis interprets monitoring data to identify underlying causes of performance deviations. Distinguishing between normal variability and abnormal behavior is critical for effective intervention. Diagnostic tools support informed decision-making by highlighting priority areas for corrective action.

Integration of monitoring and diagnostics with control systems enhances responsiveness. Automated adjustments based on diagnostic feedback can stabilize operation and reduce stress on components, extending service life.

Managing operational stability and reliability under non-stationary conditions requires integrated engineering strategies that combine design, control, monitoring, and maintenance. Isolated measures may address specific issues but fail to capture system-wide interactions.

Load management represents a key integration element. Smoothing load profiles and avoiding extreme operating regimes reduce stress and support stability. Operational planning that anticipates variability further enhances resilience.

Table 1. Engineering Elements Supporting Stability and Reliability Under Non-Stationary Conditions

Engineering Element	*Primary Function*	*System-Level Benefit*
Adaptive control strategies	*Adjust to changing dynamics*	*Stable operation*
Continuous monitoring	*Track system condition*	*Early fault detection*
Diagnostic analysis	*Identify causes of deviation*	*Targeted corrective actions*
Condition-based maintenance	*Align intervention with system health*	*Extended component life*
Load management	*Reduce operational stress*	*Improved reliability*

Operational instability and reliability failures impose significant economic costs through downtime, repair expenses, and reduced productivity. Under non-stationary conditions, these costs increase due to heightened failure risk. Investments in monitoring and adaptive control yield long-term savings by preventing unplanned outages and extending equipment life.

Reliable systems also enhance operational predictability, supporting planning and customer satisfaction. From a strategic perspective, stability and reliability contribute to competitive advantage by enabling consistent performance under variable conditions.

As industrial systems become more complex and interconnected, non-stationary operation will become increasingly common. Future engineering approaches will emphasize resilience, adaptability, and system-level integration. Advances in sensing, data analysis, and control will further enhance stability and reliability management.

Engineering education and practice must evolve to address these challenges, integrating interdisciplinary perspectives and emphasizing dynamic system understanding.

Operational stability and reliability under non-stationary conditions represent central challenges for modern industrial technical systems. Variability in loads and operating parameters introduces dynamic stress that must be managed through integrated engineering strategies.

By combining adaptive control, continuous monitoring, diagnostic analysis, and reliability-oriented maintenance, industrial systems can maintain stable and reliable operation despite changing conditions. Treating stability and reliability as dynamic attributes rather than static design properties enables sustainable system performance and long-term economic efficiency.

Keywords: *Industrial technical systems; Non-stationary operation; Operational stability; Reliability engineering; Adaptive control; System monitoring*

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